Thar Coalfield: Sustainable Development and an Open Sesame to the Energy Security of Pakistan

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Abstract. The paper discusses the role of Thar-coalfield, a 175 Billion tones reserve in enhancing the energy and combating global environmental change from the local and regional aspects. Pakistan's energy requirements are potentially huge. Being the sixth largest country in the world, with its growing population exceeded 190m by 2015. Rising population, improved living standards, increased per capita energy use, and industrialization has led to a high energy demand growth. According to latest reports the gap between the demand and supply of electricity is around 6,000MW. To meet the projected demand exploiting indigenous resources, such as Thar coalfield, a 100,000MW generation capacity reserve, could be the possible answer. Due to sustainable techniques in energy sector, 1) Coal mining is moving towards sustainable development; 2) circular economy has proven useful concept for promoting sustainable development; 3) coal industry can minimize its environmental impact from local to global level.
Besides energy goals, environmental degradation associated with the mining activity poses a serious threat to the region. Therefore, some challenges need to be addressed, e.g., discharge management issues, concerns regarding pollution control, lack of technology needed to replenish solid waste; and, increased socioeconomic and environmental pressure on the coal industry. The study discusses how sustainable development measures in Thar coalfield can run the engines of economic growth without hurting the natural environment promoting prosperity in Pakistan.

1. Introduction

For decades, the mining industry has remained a hot arena worldwide for academic and public policy research in terms of sustainable development [1, 2]. Mining industry has played a significant role in economic growth and poverty alleviation by providing millions of jobs to the locals [3, 4].
According to World Bank, Pakistan's per capita energy supplied level, the per-capita total primary energy supply (TPES) in the country was as low as half a ton of oil equivalent (toe) in 2014, which is about over a quarter of the global average, and about one-fifth that of China makes it clear that the country has to increase its energy resources against the improved living standards of its citizens. Electric-power supply has a close connection with modern energy services (such as lighting, refrigeration, and space cooling) and other services such as water treatment, communications and many aspects of transportation. The per capita availability of electric power in Pakistan was almost 472 kWh in 2014, which is almost half of world's average and just over one-seventh of China [5].
Pakistan has long suffered from an insufficient supply of electricity in relation to the demand in 2013-2014, the total shortage of energy was estimated to be 4000MW i.e.19%, while during peak hours the

shortage was as high as 7000MW which is 32% of total demand for electricity [6]. The quality of power supply in the country is also very poor, with unstable voltages and routine frequency excursions. In fact, the inadequate and unreliable supply of electricity has often considered as the main obstacle to industrial development.

Over 140 million Pakistanis suffer a 12 hours of daily power outages or they don't have an access to the power grid and the cost of these no electricity hours reaches $2.3bn annually spent in the form of candles and kerosene oil [6]. Pakistan's exceptional and stable growth of 6% GDP per annum from 2002 to 2007 increased the demand of electricity. However due to improper energy sector planning the country faced severe power cuts resulted in 2.5% GDP loss, unemployment of 0.535 million workers and a loss of $1.3 billion in exports of the country [7].

Pakistan's electricity supply is provided by WAPDA, IPPs (Independent Power Producers), GENCOs, KESC and PAEC (Pakistan Atomic Energy Commission). According to National Transmission and Dispatch Company 2015 report, IPPs (Thermal) contribute up to 9085 MW which mainly rely on gas and oil power plants. WAPDA the hydroelectric based power plants have a capacity of 6902 MW, whereas GENCOs shares 7663 MW to national grid. Apart from these major sources of electricity, other sources such as wind, Nuclear (PAEC) and coal also contribute few hundreds of megawatts to the National Electric Grid of Pakistan [8] as shown in the figure below.

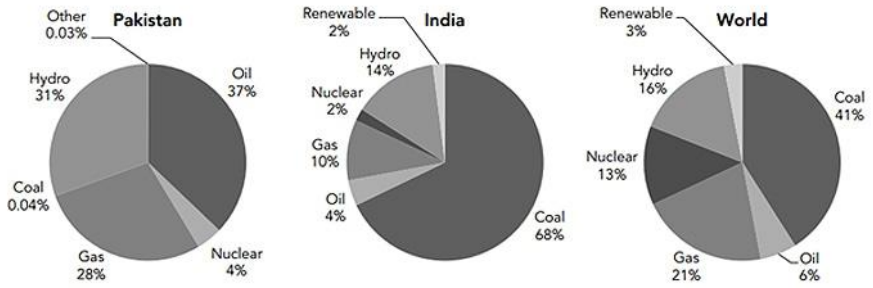

Figure 1. Type of sources used in power generation

Source: Kugelman Michael. [9].

To meet the rising energy demands [8] due to rapid population growth, the possible options are; (1) continue importing natural gas and fuel oil, (2) improve and identify alternative/renewable resources, (3) develop hydel projects or (4) exploit indigenous coal resources such as Thar coal which has a potential of generating 100,000MW per year for more than a century [10].

Now question is, will Thar coal mining be clean enough to support the sustainable development? Whether coal mining can help lighting the dark regions of Pakistan without further affecting environment? Some environmentalists argue that Thar coal should stay buried to have global temperature below 2°C, while others like Michael Kugleman a South Asian expert drawn a comparison [9] in figure 1 reflects Pakistan's reliance on coal for generating electricity. He echoed that Pakistan should be trying to access the coal from energy and economy point of view, he further added that "it is never too late for an energy-insecure country like Pakistan with huge amounts of reserves to start exploiting untouched coal, (therefore) it would be bad policy for both political and energy reasons to simply ignore nearly 200 billion tons of coal that potentially be exploited in Thar desert" [11] in an interview with Dawn news.

During recent decades, progress in the sphere of sustainable development has been made in many parts of the world. The resource-efficient *Green Economy* is one of the themes of international efforts to promote sustainable development in the 21st century. According to the World Bank, "better operations and the closure of clapped-out plants helped to push the average thermal efficiency of its coal-fired power stations from 31% in 2000 to 37% in 2010; America's remained flat, at 33%" [12].

However, there are several challenges that need to be addressed in the domestic coal industry, including better understanding of coal resources, improving coal extraction technology, and governance and regulation issues.

2. Methods and study area

The research methodologies include: a regional study; selecting the study region and information collection. For the purpose of this research, published reports and news articles, along with journal publications, were the major sources of information. The proposed research concepts used in this study is *circular economy*. The concept has been framed in response to growing concerns of resource scarcity and awareness that business is as usual unsustainable. Circular economy is a regenerative system in which an industrial shift towards resource input and waste, emission and leakage of energy can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, and recycling, also it encourages the use of renewable energy to avoid the biosphere contamination through improved systems and business models.

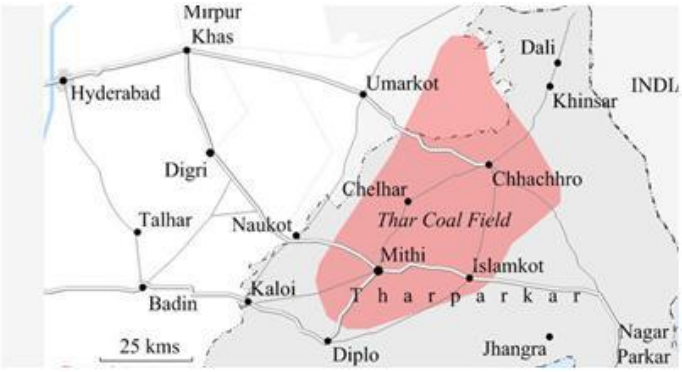

Figure 2. Location map of Thar coalfield.

Thar coalfield is located in the south-eastern part of Sindh as shown in figure 2. The first indication of coal beneath the sands of the Thar Desert was reported while drilling water wells by the British Overseas Development Agency (ODA) in coordination with the Sindh Arid Zone Development Authority (SAZDA), in 1988 [12]. Further exploration work was conducted by Geological Survey of Pakistan (GSP) and United States Geological Survey (USGS) under Coal Resources Exploration & Assessment Program (COALREAP) from 1989 to 1994 [13].

Pakistan possesses the 7th largest lignite resources in the world with nearly 200 billion tons of coal, mainly concentrated in Thar region (175 billion tons of lignite resources) [14]. Thar coalfield covers an area of approximately 9000 square kilometers. Cumulative seam thickness varies between 1.45 m and 42.6 m and the maximum thickness of an individual seam is 28.6 m [15].

3. Thar coal: quality and comparison

Sindh Engro Coal Mining Company (SECMC) engaged several renowned international organizations, including RWE Germany, SRK UK, Hagler Bailly Pakistan, Sino Coal China and NCGB China, all have conducted surveys to check the credibility of the Thar coal reserve and socio-economic impact assessments of the mining and power project [16]. The coal quality of Thar Block-II reported by Hagler Bailly Pakistan is lignite following Proximate Analysis. The raw coal accounts for 45.71% of moisture content, ash is 9.69%, volatile matters is 25.00% and 19.6% fixed carbon [16]. Environmental and Social Impact Assessment (ESIA) [17] shows that greenhouse gas emission from the Block-II power plant will be 4.9 million tons per year. Estimates using the IPCC Tier 1 methodology show a carbon emission of 101,000 kg per Tera-joule of heat input from lignite. A high content of aluminum oxide and silicon

dioxide, low ferric oxide and calcium oxide with minor amount of sulfur oxide and manganese oxide is been reported based on a chemical analysis of raw coal ash [18].
An average heating value of Thar coal (11.6 MJ/Kg) in contrast to heating value of similar kind of lignite coal reserves in other countries like, Rhineland lignite, Germany (8.9 MJ/kg) and Hungary lignite, Hungary (7.1 MJ/kg), makes Thar coalfield very feasible [18]. All above mentioned coal reserves account for thousands of megawatts of electricity against Thar coalfield's 0 MW (Thar Block-II will start generating 660MW of electricity by June 2018). The construction work on other blocks of Thar coalfield is also under process, according to A. Khan the managing director of SECMC, 4 blocks are under construction; Block-II is handled by SECMC, Block-IIIA handed to Cougar Energy (UK), Block-V is underground gasification project and Block-VI project is under Oracle Coalfields, PLC (UK) control, all four power projects will altogether add around 10,000 MW power into the national grid by 2020 [19].
Thar coalfield has an advantage of low-moderate sulfur over the world's average sulfur (2.42%) in lignite coal [20]. Oxides of sulfur are the most concerned emission pollutants from the regulatory stand point. Low sulfur content in Thar coal makes it acceptable for power generation without exceeding the emission standard for sulfur oxides [21, 22].
Apart from low Sulphur content, heating value and generation capacity of the reserve, the huge size of the reserve –175 billion tones makes a huge and adds a plus to the credibility of Thar coalfield, hence affirms it a more promising reserve that can serve the country for at least two centuries.

4. Economic impact on the region

Coal mining has a long legacy of providing jobs especially the places suffering from high poverty like Thar region. According to World Coal Association (WCA) report, even after decades, coal is still the backbone of modern electricity and currently supplies around 30% of primary energy and 41% of global electricity generation. It also predicts that the coal usage will rise over 50% by 2030, with developing countries responsible for 97% of this increase, primarily to meet improved electrification rates [23].
Pakistan's unreliable power supply is affecting the productive use of energy either directly or indirectly. The power shortage in the form of load-shedding annually cost Pakistan 14 billion Pakistani rupees (7% of GDP) [6]. Thar coal power project will mainly result in positive socioeconomic impact locally as well as regionally. With increased power generation, project (Block-II) only, will add 660 MW power to the national grid that will further be supplied to various sectors suffering from shortfall therefore, will have a positive impact on the country's economy through a better GDP. By providing additional job opportunities, project will directly impact the economy of the country with freshly created economic activities (employment and income) and indirectly by providing other opportunities like production, employment and other businesses that supply inputs to the project that will result in prosperity and stable incomes of locals [17].

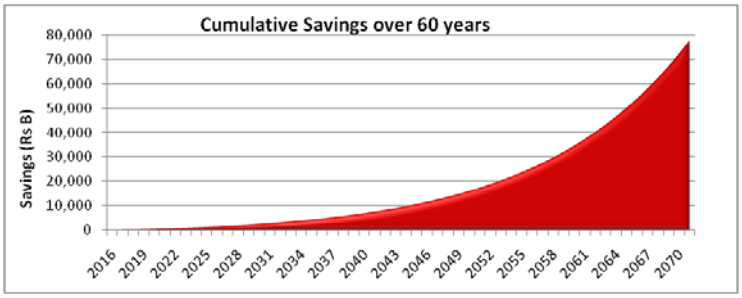

Figure 3. Net present value of savings from Thar coal project block-II [24].

According to Cambridge Energy Research Associates (CERA) estimates shown in figure 3, for oil prices Block-II will immensely benefit industrialists, domestic consumers and economy of the country by reducing the power generation cost and supplying uninterrupted electricity – net present value in Pakistani Rupees is 3.2 Trillion over a period of 60 years [24].
Low prices of electricity will help reviving the industry by providing more opportunities for investment – fallen down to 0.7% in recent years from 1.5% of GPD in 90s, and has resulted in forcible shut down of small and medium scale industries due to power crises. Also it will cut down the revenue spent on load shedding in the form of candles and kerosene [6].
Thar coal project will generate positive externalities not only in the form of hundreds of jobs but also by cumulative net savings and most importantly, regular and cost-effective energy supply needed to address the future energy mix of Pakistan.

5. Sustainable development in Thar coalfield

The coal industry around the world has made remarkable progress towards sustainable development to deal with social, environmental and economic aspects simultaneously (figure 4). The concept ensures the regional economic growth through sustainability goals, ecological and environmental protection in terms of efficient extraction of natural resources with minimum negative impact on environment. It also safeguards the social and community development of the mining area.
SECMC along with its sister concern Engro Powergen Thar Limited (EPTL) has been allocated Thar coal block-II for mining activities for two coal power plants each of 330MW capacity [16]. The adopted concept of circular economy in Thar coalfield helps improving the water quality, reducing greenhouse emission, hence successfully controlling water and air pollution.
Hagler Bailly Pakistan (ESIA) [17] has reported the sustainable development measures taken by SECMC in terms of water management out no risk to groundwater resource, the water will not be contaminated or pumped into the sea as wrongly believed, rather an effluent disposal storage pond is being constructed by the Sindh government with a treatment facility for recycling water. This treated water will be pumped to the power plant to increase the water supply.

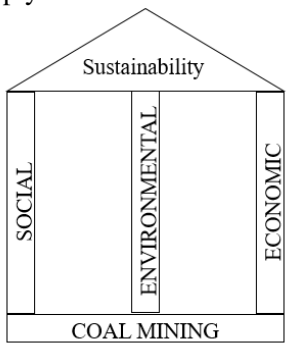

Figure 4. Coal mining sustainability model.

Regarding the coal combustion residual commonly called coal ash, only block-II project will produce 256,000 tons of ash, whereas the major part of it will be used to manufacture bricks and cement blocks [17]. Gypsum produced during the processing of coal, can be utilized in cement and marble industry. Another misconception about the large fugitive emissions that cause wind pollution has been rectified by the CEO of SECMC that the *dusk management* technique used reduces the adverse environmental impact and makes risk minimum and manageable [16].
The hazardous waste storage facility by SECMC at the site guarantees the storage and handling facility of the effluent wastes generated and emissions from the power plant are kept within National Environmental

Quality Standards (NEQS). An improved coal extraction and an advance processing technology has been adopted to minimize GHG emissions and environmental impacts such as the use of *Electrostatic Precipitator* in generators to minimize particulate emissions of fly ash and unburned carbon, whereas to control the emission of Sulfur dioxide (SO_2), limestone will be injected to circulating fluidized bed boiler (CFB) which converts Sulfur into gypsum and controlled emission of oxides of nitrogen will be provided by low NO_x burners [17].

6. Opportunity cost

Pakistan's reliance on mining for generating electricity till this day coal is almost nothing, therefore, there is a need to spread awareness among public about the threats coal mining poses regionally and globally.
Considering all sustainable measures, practically every mining activity especially coal mining somehow disturbs the natural environmental. Coal mining has mainly been criticized for its large amount of waste produced during coal mining, especially during the processing of coal. Seeing all under construction Thar coal power projects, only block-II will produce 256,000 tons of hazardous wastes annually. There are various risks involved regarding these wastes including the destruction of landscapes and habitats, emission of carbon and methane gas, acidification of the soil due to sulfur presents in sinkholes which leaves surface water and soil permanently hazardous for plants and animals.
The health impact of particulate matters in Thar coalfield due to open-pit mining is of greater importance than air pollution because, the level of PM_{10} and $PM_{2.5}$ received are above national standards which can cause diseases like black lung asthma, kidney disease and hypertension [25]. The emission of arsenic associated with the volatile organic matter of coal during combustion may cause environmental pollution in Thar region [21].

7. Suggestions

- Pakistan government needs to set a guiding ideology of national development that reflects the economic growth and supports the ecological sustainable development.
- There is a need to formulate number of laws, policies and strategies and their implementation is strictly needed, that can for example promote awareness about the Clean Production, circular economy production, climate change and other general laws of coal industry among the public.
- And lastly there is a serious need of public participation and corporation for their social responsibilities which is helpful in spreading environmental awareness about coal mines.

8. Conclusion

It is indubitable that Thar coalfield have potential to be financially profitable, technically reliable, environmentally sound and socially responsible, therefore, can meet the power needs of Pakistan for two centuries at least. And circular economy along with other sustainable techniques not only enhances the economic performance of Thar coalfield by regulating the needed supply of electricity which has paralyzed the economy of the Pakistan and by creating direct and indirect employment and business opportunities to alleviate poverty, but also reduces greenhouse gas emissions, controls water and air pollution and helps in addressing the environmental degradation problems. However the success of the coal industry and environmental development still largely depend upon the Pakistan governments' guiding ideology on development, strict enforcement of laws, policies, strategies, and public corporation and participation.

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